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Discussion

Troubleshooting the problems arising from sustainable development

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ABSTRACT

Sustainable development as a concept of societal development encompasses some problems that need to be addressed carefully. They relate to overcoming the technical limits of individual systems, reducing environmental impact, social inclusion, green economic progress involving all stakeholders, limiting the impact of human activities, etc. Over the past few years, as a result of the increasingly pronounced climate change, more and more studies are addressing these problems and stress the importance of sustainable development. The key to sustainable development are, therefore, the solutions to the problems currently encountered by various stakeholders, that together contribute to the preservation of the environment for future generations. This is no longer based on the goodwill of individuals, but has become the responsibility of the entire generation. This article presents some examples of the solutions for the problems arising from sustainable development and is an overview of recent scientific achievements in the field of sustainable development that emerged from recent Sustainable Development of Energy, Water and Environment Systems (SDEWES) conferences. As such, it acts as an editorial paper for the virtual special issue of the Journal of Environmental Management, that is dedicated to the SDEWES2017 conference.

1. Introduction

As a result of a successful and highly recognized first Journal of Environmental Management (JEMA) Special Issue (SI) dedicated to the Sustainable Development of Energy, Water and Environment Systems (SDEWES) conferences in 2016 (Mikulčić et al., 2017), the cooperation been JEMA and SDEWES conference series has been continued this year. This JEMA Virtual Special Issue (VSI) will further increase the knowledge on solutions for problems arising from the sustainable development and will ensure that JEMA's international community, consisting of scientists belonging to different disciplines, are aware of the progress in this research area.

In 2017, the 12th SDEWES Conference (SDEWES 2017) was held from 4th till 8th October in Dubrovnik, Croatia. The conference brought together 530 scientists, researchers, and experts in the field of sustainable development from around 60 countries. 450 papers and 100 posters were presented, and the conference included 4 invited lectures, 12 special sessions and 2 panels with some of the most recognized experts in the field of sustainable development. The papers in this VSI are based on archival articles presented at the SDEWES 2017 Conference. From those 450 archival submissions, 41 were invited to contribute to this VSI. After a rigorous JEMA review process, 29 papers were accepted for publication, and form this VSI. These 29 papers can be classified into three main research fields: Experimental analysis and novel techniques (8 papers); Mathematical modelling (12 papers) and Energy systems (9 papers). This paper shortly evaluates the named three groups of papers, and gives the JEMA readers a sense of continuity, by reviewing some previous publications in the same research area.

2. Background

The *Experimental analysis and novel techniques* in the investigation of contaminated water and soil, hazardous waste, and air pollution have been studied in a number of papers. Boeykens et al. (2018) experimentally investigated the use of agro-industrial waste for lead and chromium biosorption. The decrease of trace elements in soil by using furnace slag was investigated by Pistocchi et al. (2017). The kinetic perspective of low temperature hexavalent chromium removal with metallic iron was analysed by Gheju et al. (2017). Placek et al. (2017) studied over a period of 18 months the effect of organic and inorganic amendments on heavy metal immobilization in soil and organic carbon sequestration. The pyrolysis of tyre powder using microwave thermogravimetric analysis was investigated by Song et al. (2016). Catalytic

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co-pyrolysis of torrefied yellow poplar and high-density polyethylene was analysed by Kim et al. (2017).

Investigation on groundwater remediation by adsorption of ammonium was investigated by Vocciante et al. (2018). Treatment of swine wastewater was the topic of the study by Pena et al. (2017). Wastewater from nuclear power plant was studied by Haslik et al. (2017). Treatment and cleaning of wastewater from a manufacturing textile mill was investigated by Yukseler et al. (2017). The integration of water network between plants was the topic of the study by Ibrić et al. (2017). Finally, using the fluorine plastic heat exchangers, Xiong et al. (2017) studied the water and latent heat recovery from flue gases of a coal fired utility boiler.

Production of bio-based hydrocarbon fuels and their use has been the topic of several studies. The use of the ethanol-blended fuels in marine vehicles was studied by Davis (2017). While Chng et al. (2016) investigated the production of bioethanol using lipid-extracted biomass from *Scenedesmus dimorphus*. Production of biofuels from food waste and waste cooking oil was investigated by Chuah et al. (2017), and biodiesel production from waste cooking oil was studied by Sheinbaum et al. (2015). The methyl ester loss in the glycerol phase during biodiesel production was studied by Hájek et al. (2018). Gasification of municipal solid waste was studied by Werle and Duzdiak (2015). Pyrolysis of perennial grasses and the corresponding syngas production was studied by Juchelková et al. (2015).

Air pollution from various industrial processes was the topic of different studies. Mikulčić et al. (2013), and in the subsequent study Mikulčić et al. (2015) investigated the particle and gaseous emissions originating from a cement calciner. Hartmann et al. (2015), and the subsequent study by Raclavska et al. (2017), studied the handling of hazardous waste from an incinerator plant. The absorption of carbon dioxide in monoethanolamine solution from flue gas in coal based thermal power plants was investigated by Singhal and Manjare (2018). Cao et al. (2017) analysed the removal of particles and trace elements from coal-fired power plant flue gases.

Mathematical modelling of various processes and applications has been the research topic of several papers. The modelling techniques have been used to analyse optimal design of cogeneration units in the industrial sector (Gambini and Vellini, 2018), heat and power units (Koller and Hofmann, 2018), coupling of cleaner production with a day-ahead electricity market (Perković et al., 2017), transient operating conditions of gas turbines (Pires et al., 2018), optimal heat-exchanger layout for heat recovery steam generators (Čehil et al., 2017), influence of the compression ratio on knock occurrence in a conventional dual fuel engine (Sremec et al., 2017), sustainable practices for urban systems (Kilkiş, 2018), high-energy demand in urban space with scarce availability of renewable energy sources (Mutani and Todeschi, 2018), evaluation of the sustainability of different enterprise resource planning systems (Chofreh et al., 2018), upstream fish migration along rivers (Yoshioka et al., 2018), urban vegetation growth and corresponding carbon sequestration in urban areas (Chan et al., 2018), etc. The modelling techniques have been used extensively to improve the energy efficiency and reduce pollutant emissions from industrial processes. Operation of a dry desulfurization process for oxy-fuel integrated gasification combined cycle power generation was investigated by Kobayashi and Akiho (2016). Improvement in a co-current, fixed bed biomass gasification facility was studied by Mikulandrić et al. (2015). The waste heat recovery system in a sewage sludge dryer was studied by Tańczuk et al. (2016). Chemical plants and their integration with sugarcane biorefineries were studied by Machado et al. (2018). Combustion of waste in a wood-fired grate boiler with recycled flue gas was investigated by Rajh et al. (2016). Iron ore sintering process in the steel industry was studied by Cheng et al. (2016), and in the subsequent study by Cheng et al. (2017). The retrofitting strategies for improving the energy and environmental efficiency for the aluminium industry was investigated by Royo et al. (2018). The options for fuel use reduction and limitations of pollutant emissions originating from cement manufacturing processes were studied by Mikulčić et al. (2016a), and in a later study by Mikulčić et al. (2016b).

Over the years, Computational Fluid Dynamics (CFD) simulations have proven to be a valuable tool when it comes to the detailed research of different physical and chemical processes. Orbegoso et al. (2017) analysed numerically two types of solar air heating collectors used for cocoa bean solar drying. The strong endothermic calcination reaction inside a pipe reactor was CFD modelled and compared to experimental measurements by Mikulčić et al. (2012). Milani et al. (2017) analysed the ceramic kiln energy efficiency improvements using a numerical approach. The heat transfer from a finned housing of an electric motor was investigated by Grabowski et al. (2016). Heat transfer for an open heat exchangers used in jaggery production modules was studied by La Madrid et al. (2016). The design of a tidal kinetic turbine prototype was numerically investigated by Barbarelli et al. (2017). The selective non-catalytic NO_x reduction process in an incinerator, and the application of selective catalytic reduction for NO_x reduction in the diesel engine flue gas was analysed by Baleta et al. (2016) and Baleta et al. (2017), respectively. The impact of the fuel injection timing and ignition position in a direct-injection natural gas engine was studied by Wang et al. (2017). The influence of biofuel on pollutant formation in diesel engines was investigated by Petranović et al. (2017). Power generation by large gas engines was investigated by Pirker and Wimmer (2017). Using the CFD modelling approach, Bargiel et al. (2017) analysed the design improvement and optimization of a natural gas-fired thermoelectric generator.

Energy systems has been the topic of research of many previous papers, especially related to the transition from the fossil fuel based to the renewable energy source (RES) based energy system (Vidal-Amaro and Sheinbaum-Pardo, 2018), and the integration of large shares of variable RES into the electricity system (Auer and Haas, 2016). The complexity of this transition has been analysed in several papers: the electricity generation with the piezoelectric material integrated into a shoe (Turkmen and Celik, 2018); the concept of an energy positive neighborhood (Ala-Juusela et al., 2016); nearly zero energy greenhouse concept (Yildirim and Bilir, 2017); buildings energy performance (Hrvat and Dović, 2016); geothermal energy assisted milk powder production (Yildirim and Genc, 2017); area-based analysis of fuel poverty vulnerability in an urban space (März, 2018); impacts of electricity grid tariffs on the flexibility of electricity use for heat generation (Kirkerud et al., 2016); energy and desalinated water supply by renewable sources for an island in the Mediterranean Sea (Calise et al., 2017a); the energy demand and the future of transport sector in the sustainable energy systems (Dominković et al., 2018); the food-energy-water nexus analysis on a national level (Schlör et al., 2018a); energy security and energy supply analysis on a transnational EU level (Matsumoto et al., 2018). Variable RES (VRES) exploitation acquires special attention, as VRES change the traditional ways of the power production sector, and require demand response technologies for their large share integration (Spiegel, 2018). The demand response technologies are an effective way for harmonizing of power demand and supply when there is a high share of VRES (Leobner et al., 2018). Another option for harmonizing power demand and supply with a high share of VRES is energy storage (Calise et al., 2017b). Energy storage technologies are required to make full use of renewable energy sources, and these technologies include electrochemical batteries (Posada et al., 2017), thermal energy storages (Urschitz et al., 2016), compressed air energy storages (Hämmerle et al., 2017), energy storage based on calcium looping (Ortiz et al., 2017), etc.

To conclude, these are just some of the SDEWES related papers that have contributed to the knowledge increase in the research area of sustainable development. However, there are still many papers dealing with these research topics and can be found in the previous SDEWES Special Issues and Volumes.

3. This virtual special issue papers

There are eight papers in this VSI dealing with the *Experimental analysis and novel techniques* theme. Galli et al. (2018) experimentally evaluated the production and application of O_2 enriched air produced by fresh and salt water desorption in chemical plants. The study showed that salt water desorbs less air but the effect on its concentration is negligible, when compared with fresh water. Deng et al. (2018) studied the catalytic effect of potassium salts on oxy-biomass combustion in different atmospheres. The study showed that the catalysis degree in an O_2/CO_2 atmosphere is stronger than in an O_2/N_2 atmosphere. Musil et al. (2018) compared the effect of potassium hydroxide and potassium tert-butoxide catalysts on biodiesel production from rapeseed oil. The study showed that the type of catalyst used has a direct influence on the quality of the obtained biodiesel. The unburned carbon from bottom ash by means of pyrolysis-GC/MS was investigated experimentally by Růžičková et al. (2018). The study was performed in order to identify undesirable combustion products that contribute to an increased emissions of particulate matter from residential boilers. Raclavská et al. (2018) studied the chemical composition of tetrapak biochar produced at pyrolysis temperatures of 400, 500, 600 and 700 °C. The study showed that the pyrolysis temperature is a decisive factor in the applicability of biochar in agriculture. Koval et al. (2018) investigated the dust particles in an urban environment, to ensure that industry and community coexist in a mutually beneficial and sustainable manner. The study showed that, in the studied area, all samples consisted predominantly of particles of organic origin, and in lower concentrations of dark material particles of mainly inorganic origin (low reflecting material, mainly stone dust, clay, soot, rubber and soil), combustion char and metal particles (rust and iron oxides). Fijalkowski et al. (2018) performed a 3-year experiment on degraded soil from a terrain of a steel mill, in order to determine whether sewage sludge could be an effective fertilizer for energy crops and simultaneously play a positive role in soil improvement via phytoremediation. The offset use of mineral soil fertilizers by plant growth-promoting rhizobacteria soil biopreparation and soil amendments was studied by Grobelak et al. (2018). The study showed that alternative fertilization and bacteria soil biopreparation can be used as an alternative soil bioremediation option.

Twelve papers in this VSI are in the *Mathematical modelling* theme. Rajh et al. (2018) used an advanced CFD modelling method to numerically investigate the performance of a grate-fired boiler. The study results showed that by optimizing the air and recycled flue gas jet configuration, a reduction in carbon monoxide emission by up to 86% can be achieved. The study furthermore showed that the presented CFD method can serve as a useful tool for novel design of grate boilers and optimization of the combustion process inside them. Bešenić et al. (2018) numerically investigated the nitrogen oxides emissions during solid fuel combustion. The study showed that the presented model predicts the nitrogen oxides formation well and is in good correlation with experimental data. In a subsequent study, Liu et al. (2018) investigated low NO_x combustion and selective catalytic reduction flow field optimization for a coal fired boiler by using CFD as a research tool. The study showed that by optimizing the flow field a reduction in NOx emissions at the furnace exit can be achieved. Furthermore, the study showed that after optimization, the consumption of liquid ammonia can also be reduced. Bou-Fakhreddine et al. (2018) modelled open water evaporation for the Qaraoun lake in Lebanon, to estimate the daily evaporation. The study results were further used to carry out an economic impact assessment of evaporation losses from Qaraoun lake on the hydropower production and on the irrigation sector. In a subsequent study Sahin et al. (2018) evaluated various forms of a proposed tiered scarcity adjusted water budget and pricing structure using a holistic systems modelling approach. The study showed that the tiered scarcity adjusted water budget and pricing structure presented was preferable to restrictions since it could maintain water security more equitably with the lowest overall long-run marginal cost. Water resource management was studied also by Alam et al. (2018). This study analysed the water quality dynamics using a stochastic differential equation model. The presented model showed the potential to correctly predict different water quality parameters. Minimization of freshwater requirement and wastewater generation within the water network was mathematically analysed by Mabitla and Majozi (2019). The study showed that by integrating graphical and mathematical techniques, a reduction in simulation time of up to 85% can be achieved. This suggests that the presented method is very promising for large scale water network problems. Yaegashi et al. (2018) investigated the sustainability of bird population management using a stochastic differential equation model. The study showed that optimal population management policy maximizes a performance index that covers the cost of countermeasures, the loss of riverine fish, and the ecosystem services provided by the bird. Carli et al. (2018) made an analysis of the sustainable development of energy, water and environmental systems for four metropolitan city areas. The study showed the usefulness of the applied analysis for the local government on how to formulate the sustainable development strategy for a metropolitan city. Cantore and Cheng (2018) studied the international trade of environmental goods using gravity models. The study results showed that environmental regulatory stringency is a key factor for environmental goods trade. Other factors that also play a role in environmental goods trade include increased capacity to innovate, cultural ties, geographical proximity and financial uncertainty. Peri et al. (2018) compared the performance of a waste management system in a city in the South of Italy for two scenarios using Ecological Footprint indicators. The study results showed that the effects generated by the involved transportation vehicles are non-negligible, compared to those generated by the other segments of the waste management system. The impact of pollutants from waste transportation was investigated by Nevrlý et al. (2018).

There are nine papers dealing with the *Energy systems* theme. Schlör et al. (2018b) investigated the resilience space of German energy system using the vector analysis. The study showed that a resilient development of the German energy system should be supported by a political discourse on objectives and the instruments of the energy transition process. In a subsequent study, Schlör et al. (2018c) studied the food energy water-nexus (FEW-Nexus) in Germany. The study showed that political institutions and inclusive economy, are responsible for enabling a fair society in front of the veil of ignorance. The water-energy-food (WEF) nexus was further investigated in the study by Terrapon-Pfaff et al. (2018). The study showed that major nexus challenges need to be faced at local level. Furthermore, the study identifies the complex links that exist between sustainable energy projects and the food and water sectors, and highlights that these needs are currently not systematically integrated into project design or project evaluation. Jääskeläinen et al. (2018) investigated the impacts of severe drought on the future Finnish energy system using the Energy PLAN simulation tool. The study showed that, due to the well interconnected Nordic energy system, a drought affecting only Finland would not cause a severe energy security threat. However, a severe drought in the Nordics could cause a serious energy security threat to Finland. Oil price reduction and increasingly stringent environmental regulations are forcing petrochemical companies to improve their energy efficiency. Due to this reason, Ulyev et al. (2018) studied the energy efficiency improvement of a crude oil distillation process. The study showed that energy efficiency improvement of a distillation unit can be achieved by the retrofit of the heat exchange network, which allowed reducing natural gas consumption by 0.98 t/h. To increase the energy efficiency and minimize the operating and maintenance costs of a cooling system in a humid environment, Saab et al. (2018) assessed the Variable Refrigerant Flow (VRF) technology using different refrigerants. The study showed that energy savings of 32% can be obtained with variable evaporators and condenser speed, and variable compressor frequency. Using the Monte Carlo analysis method, Ricciu et al. (2018) assessed the Predicted Mean Vote (PMV) index, used to determine the indoor

thermal comfort and energy consumption in conditioned buildings. The study showed that an uncertainty propagation method could improve PMV model application. Using a specific method, Del Moretto et al. (2018) evaluated the potential CO_2 emission reduction and energy efficiency increases for campsites in a protected area. The study results showed that the considered campsites, located in a highly protected area, present a significant positive aspect in terms of CO_2 emission reduction and of energy efficiency increase. Proskuryakova (2018) examined the classic energy security concepts and showed that these classical concepts do not account for the latest technology changes. The study gives suggestions for revision of energy security concepts through integration of future technology considerations.

4. Conclusions

This VSI introduction paper addresses a selection of recent research works on three topics named as: Experimental analysis and novel techniques; Mathematical modelling; Energy systems. These three themes of papers are just a small part of sustainable development problems that researchers over the world encountered. All the solutions, presented in the papers reviewed in this article, represent a knowledge gain, and further increase in human awareness of responsible and sustainable development. The knowledge of negative human activities is especially important as it contributes to greater lucidity for environment preservation for future generations. This is no longer based on the good-will of individuals, but has become the responsibility of this generation. Some examples and solutions to the problems arising from sustainable development concept that emerged from recent Sustainable Development of Energy, Water and Environment Systems conferences are overviewed in this paper. The Guest editors believe that the papers selected for this VSI will be of interest to Journal of Environmental Management readers.

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